Sebastien B. Lambert: Baseline and Site Repeatability in the IVS Rapid Network, IVS 2006 General Meeting Proceedings, p.296–299
http://ivscc.gsfc.nasa.gov/publications/gm2006/lambert2

Baseline and Site Repeatability in the IVS Rapid Network

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Abstract

Lengths of 88 baselines ranging from 1,000 to 12,400 km and coordinates of 15 sites participating in the IVS rapid 24-hour networks R1 and R4 are studied. The wrms of the baseline lengths increases by 1.57 mm per thousand kilometers, which can be interpreted as a loss of accuracy when the VLBI networks uses longer baselines. Two baselines, linking the TIGO antenna at Concepción (Chile) to Fortaleza (Brazil) and to Algonquin Park (Ontario), have wrms values significantly above this level. An analysis of the sensitivity to the tropospheric gradients reveals that their determination degrades the determination of baseline lengths below 8,000 km by about 5 mm but may improve the determination of longer baseline lengths by up to 1 cm. Considering the site coordinates, the estimation of the gradients improves the determination, except for TIGO whose Up and North components are significantly degraded.

1. Description of the Solution

Local site positions and baseline components are derived from R1 and R4 experiments between January 1st, 2002 and June 30th, 2005 (358 experiments including the CONT02 campaign which has an R1-like geometry). Algonquin Park (Ontario) is adopted as a priori station with fixed coordinates and velocity in ITRF2000. Polar motion and UT1 − UTC are not estimated; instead a priori values are taken from IERS Bulletin A ([1]). The no-net-rotation is applied to the 212 ICRF defining sources. Other radio sources positions are estimated as arc parameters along with site coordinates, nutation offsets and length-of-day. Ocean tidal and atmospheric pressure loading are not applied. Niell's mapping functions ([3]) are used for the atmospheric dry and wet components. The computation was done at USNO using the CALC/SOLVE geodetic VLBI analysis software package developed at NASA/GSFC. To eliminate edge effects caused by the arbitrary beginning of the two rapid turnaround session series and the influence of the coseismic displacement due to the 2002 Denali fault earthquake near Fairbanks ([2]), which affected significantly the position of the GILCREEK antenna, the time series analysis of the baseline lengths and site positions is started in January 2003.

2. Baseline Lengths

Figure 1 plots the baseline length repeatability (weighted root mean square after having removed a trend and an annual signal) versus the baseline length. The wrms points are contained in a cone centered at the origin with an aperture of about 20 degrees. A linear regression line can be fit to model the wrms as a function of baseline length. The slope is 1.57 ± 0.03 mm per thousand kilometers. This value can be interpreted as the degradation of the accuracy of the VLBI network when long baselines are used instead of short ones. The equivalent geometric time delay is 5.26 ± 0.10 ps per thousand kilometers. Note that this value has to be compared to the mean postfit residual rms of the solution of 20.37 ps.

Two baselines linking TIGOCONC (Concepción, Chile) to FORTALEZA (Brazil) and to ALGOPARK (Canada) appear significantly above the linear regression line. Their lengths are about 5,000 km and 8,000 km respectively. Seven other baselines involving TIGOCONC in this study do not present such a significant departure, even for baselines longer than these two. I would like to point out that (i) the two baselines cited above are used in more that 60 sessions and are therefore not affected by a lack of data, and (ii) that Figure 1 reflects the effect of the current network and analysis strategy for the baseline length determination. Therefore, the results concerning a site or a set of sites cannot be related only to the site or to the set of sites, but should be considered with great care as they potentially include other sources of error due to observational and/or analysis strategies.

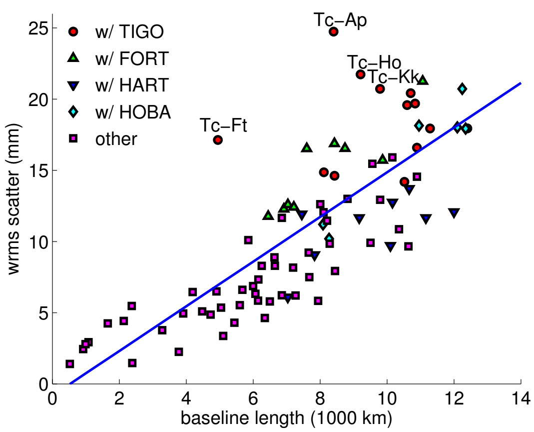

Figure 1. Baseline length repeatability versus baseline length. Ap: ALGOPARK, Ft: FORTLEZA, Ho: HOBART, Kk: KOKEE, Tc: TIGOCONC.

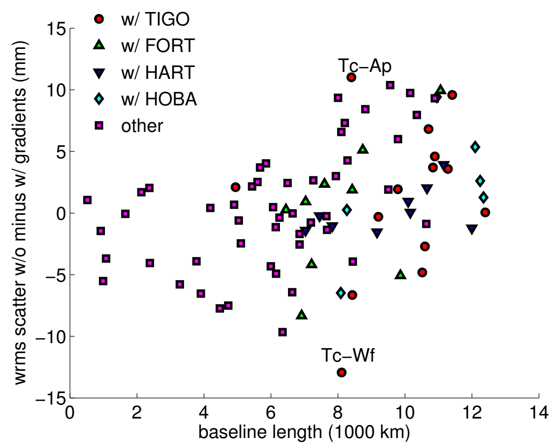

Figure 2. Difference of baseline length repeatability between unmodeled and modeled troposphere gradient solutions. Ap: ALGOPARK, Ft: FORTLEZA, Ho: HOBART, Kk: KOKEE, Tc: TIGOCONC, Wf: WESTFORD.

Figure 2 displays the variation of the wrms when the tropospheric gradients are or are not estimated as a function of baseline length. A positive value indicates that estimating the gradients improves the results. The mean effect of the tropospheric gradients appears to stay around zero with a deviation of ± 1 cm, implying that omitting the gradients causes an underestimation or overestimation of the baseline length by less than 1 cm (4.8 ps). For baseline lengths below 8,000 km, the mean variation is negative: the gradients degrade the estimates of the length. In this range, there appears to be no clear link between the variation and the baseline length, showing that the sensitivity to the atmosphere is site-dependent (as opposed to baseline-dependent such as the wrms itself, as noted above). However, for longer baselines, it appears that estimating the gradients can improve the baseline length determination by up to 1 cm. Note that the baseline TIGOCONC-ALGOPARK is significantly improved, whereas TIGOCONC-WESTFORD (MA, USA) is significantly degraded, although they are very close.

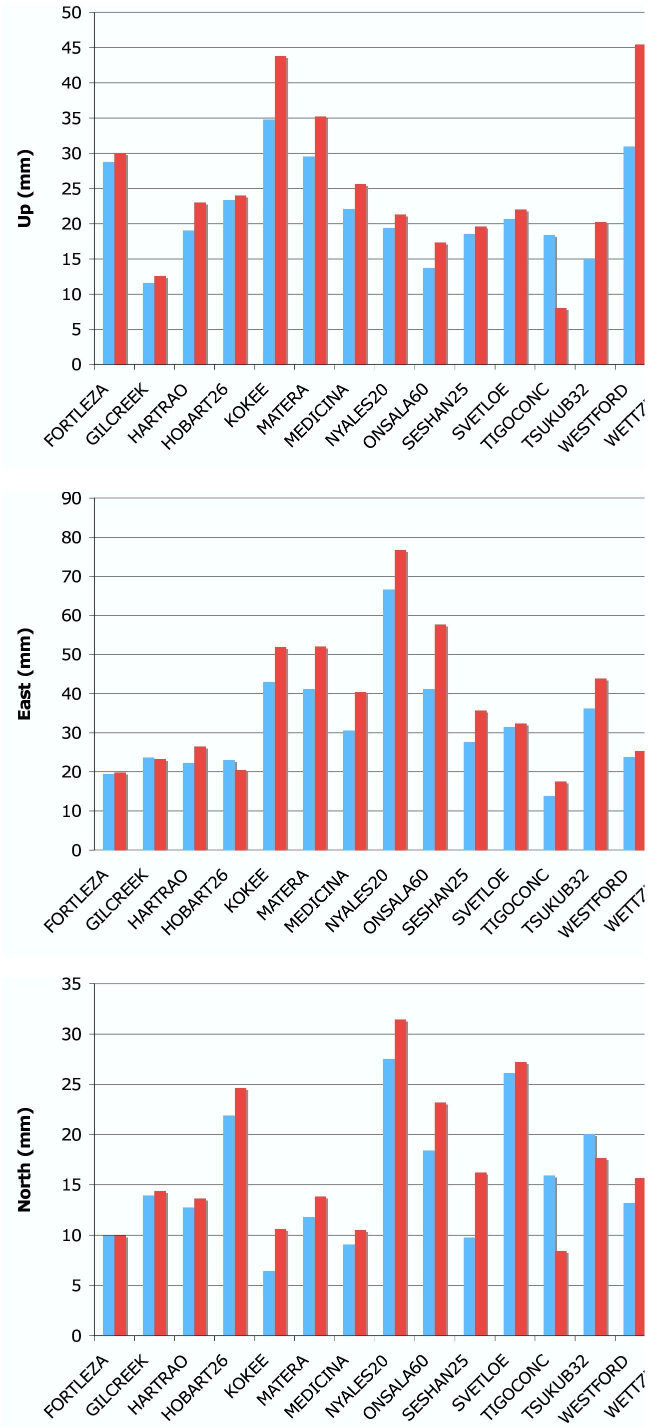

Figure 3. Wrms scatter of the Up, East and North components of all sites involved in the R1 and R4 networks between 2002 and 2005.5. Left bar: wrms when the gradients are estimated. Right bar: wrms when the gradients are not estimated.

3. Site Positions

Figure 3 shows the wrms scatter of the site components with and without estimating the troposphere gradients. The wrms is generally improved (sometimes insignificantly) by estimating the gradients (see for instance KOKEE, ONSALA, WESTFORD, WETTZELL). The case of TIGOCONC is interesting because the wrms is significantly degraded on vertical (Up) and North components when the gradients are estimated. However, the East component is not very sensitive. As can be seen in meteorological datasets (e.g., NCEP/NCAR Reanalysis project) the coastal site of TIGO presents a strong departure from azimuthal symmetry in air temperature and water vapor quantity in the atmosphere, mainly due to local geography (between Pacific coast and Andes mountains), strongly perturbing the refractivity. It results that the East component of the troposphere gradients (combination of temperature and humidity contributions) is much stronger than the North component. A difficulty in estimating the gradients with the current models could partly explain these results.

References

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[3] Niell, A.E. 1996, Global mapping functions for the atmosphere delay at radio wavelengths, J. Geophys. Res., 101, 3227.